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Predictors of Pain and Functional Outcomes after Operative Treatment for Rotator Cuff Tears

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Abstract

Background: Optimal patient selection is key to success of operative treatment for cuff tears. We assessed predictors of pain and functional outcomes in a longitudinal cohort of patients undergoing operative treatment.

Methods: From 03/2011 to 01/2015, a cohort of patients with rotator cuff tears undergoing rotator cuff surgery was recruited. Patients completed a detailed health and demographic questionnaire, standardized shoulder questionnaires including the Shoulder Pain and Disability Index (SPADI), and underwent a MRI. Patients received follow-up questionnaires at 3, 6, 12, and 18 months. We assessed longitudinal predictors of SPADI using longitudinal mixed models. Interactions with follow-up duration after surgery were also assessed.

Results: In our analysis (n=50), a lower fear-avoidance beliefs questionnaire physical activity score (FABQ; p=0.001) predicted a lower SPADI score (better shoulder pain and function). Those consuming alcohol 1–2 times per week or more had lower SPADI scores as compared with those consuming alcohol 2–3 times per month or less (p=0.017). Both of these variables had a significant interaction with duration of follow-up. Other variables including socio-demographic characteristics, MRI characteristics such as tear size and muscle quality, shoulder strength, and

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variations in surgical techniques/performance of adjuvant surgical procedures were not significant predictors of SPADI.

Conclusions: Those with higher fear avoidance behavior and alcohol use of 1–2 times/week had worse shoulder pain and function at 18 months of follow-up. These data can be used to select optimal candidates for operative treatment of rotator cuff tears and assist with patient education and expectations prior to treatment.

Level of Evidence: Level II; Prospective Cohort Design; Treatment Study

Keywords

Rotator cuff; surgery; predictors; outcomes; SPADI; shoulder pain; cohort

INTRODUCTION

An estimated 272,148 rotator cuff repairs were performed on an ambulatory basis in the United States in 2006[6, 14] There has been an increase in surgery as the initial treatment for rotator cuff tears over time[30]. Optimal outcomes of operative treatment for rotator cuff tears are achieved by patient selection based on characteristics that predict better pain and functional outcomes after surgery. Few studies have analyzed a limited number of factors associated with better outcomes after operative treatment[3,5,8,12,18,19,21–23,26–28]. A comprehensive longitudinal analysis of possible predictors of better outcomes after operative treatment in a well-defined multi-center cohort is lacking as per our assessment.

In a longitudinal multi-center cohort of patients with rotator cuff tears, we assessed predictors of better shoulder pain and function after surgery. This information can be used to guide clinicians and patients in identifying optimal candidates for surgical treatment of rotator cuff tears.

MATERIALS AND METHODS

Patient Population

Between 03/2011 and 01/2015, the Rotator Cuff Outcomes Workgroup (ROW) cohort study recruited patients 45 years and older with symptomatic (for at least 4 weeks) rotator cuff tears undergoing operative treatment. Patients were recruited from Sports/Shoulder clinics in 3 academic and 1 community setting. Exclusion criteria were a current shoulder fracture, prior shoulder surgery (on the index shoulder), and active cervical radiculopathy (elicited as neck pain radiating to shoulder/arm/hand). Patients provided informed consent and the study was approved by our Institutional Review Boards. Although this analysis was performed in patients undergoing rotator cuff surgery, the entire ROW cohort recruited patients with and without tears and also those undergoing operative and non-operative treatments.

Structured History Questionnaire and Outcome Measures

A history questionnaire and outcome questionnaires were administered to each patient at each time point. The history questionnaire was abbreviated for follow-up. The history questionnaire elicited comprehensive and structured information on patient demographics,

comorbidities, symptoms, smoking/alcohol habits, and patient expectations from treatment. Performance of manual labor on a daily basis in the patient's current job or last job (if retired) was also asked. The physical activity scale of the Fear-Avoidance and Beliefs questionnaire (FABQ) was designed by Waddell et al[31] to assess fear-avoidance beliefs about physical activity in patients with low back pain. We modified the FABQ physical activity questions (4 items that contribute towards scoring) in this scale by using the term "shoulder" instead of "back". The scale has 24 possible points with a higher score indicating worse fear-avoidance behavior with physical activity in relation to the shoulder. Mental health was assessed using the Mental Health Inventory (MHI-5)[2], a component of the 36-item Short Form Health Survey[32]. MHI-5 scores range from 0 to 100. A score of ≤68 on the MHI-5 is indicative of a probable mood disorder (including depression)[17,29].

Shoulder outcomes were assessed using the Shoulder Pain and Disability Index (SPADI)[24], a standardized 13-item questionnaire. SPADI has a pain scale (5 items) and a disability scale (8 items). SPADI scores range from 0 to 100 with lower scores reflecting better shoulder pain and function.

Strength Testing

Strength testing was performed using a hand-held dynamometer in abduction, external rotation, and internal rotation by trained research assistants. Both the affected and contralateral shoulders were assessed and a mean of two consecutive measurements that were at least 10 seconds apart was used in our analysis. Our detailed protocol for standardized strength testing has been previously described[15, 20]. Strength testing using a dynamometer has good intra-rater and inter-rater reliability[11]. We used a ratio of the affected shoulder versus the contralateral shoulder strength in the analysis.

Surgical Characteristics

A surgery report form was used to determine whether a biceps tenodesis or tenotomy was performed and the technique used when performing the rotator cuff repair. The technique was classified into single row, double row, and other (open repair or transosseous equivalent). The surgery report form was completed by the attending surgeon.

Diagnostic Imaging

Shoulder MRI images were read in a blinded fashion by consensus by two shoulder experts (L.D.H. and N.B.J., or J.E.K. and N.B.J.). Our previous work has shown good inter-rater and intra-rater reliability for these MRI readings as compared with a reading by a musculoskeletal radiologist[13]. Kappa values ranged from 0.75 to 0.90 for tear presence, tear size, and tear thickness[13]. MRI features including tear thickness, tear size in longitudinal and transverse planes, fatty infiltration of the rotator cuff muscles, tendon retraction, and rotator cuff muscle atrophy were assessed. Criteria for each of these measurements follows standard nomenclature and has been previously described[13].

Diagnosis of Rotator Cuff Tear

Rotator cuff tears were diagnosed based on the clinical impression of a sports/shoulder fellowship trained attending physician and evidence of structural deficit on MRI. Biceps

tendon pathology was diagnosed based on the clinician's impression since imaging can be negative even if the patient has symptoms corresponding to biceps pathology or vice versa. A MRI was unavailable for 2 patients in the cohort.

Longitudinal Follow-Up

Patients were followed at approximately 3, 6, 12, and 18 months after completion of baseline visit. Patients were mailed follow-up questionnaires with a prestamped envelope. Patients received phone or email reminders if they did not return the questionnaires, and eventually a call from the study Principal Investigator if questionnaires were still not returned. All 50 patients had at least 1 follow-up from baseline. At 18 months 35 patients were available for analysis.

Statistical Analysis

Potential factors associated with treatment outcomes (SPADI) were assessed over 18 months of follow-up. Since variable effects can change over time, a total of 27 variables and their interactions with time were assessed. An a priori sample size calculation was not performed for this analysis. Variables included in our analysis were categorized into demographics, patient symptoms, comorbidities, personal habits, shoulder strength, and patient expectations. For partial-thickness tears, size of tear was given a value of 0 for the analysis since there is no accepted standard methodology to calculate size in partial-thickness tears. Race and patient expectations after treatment could not be used in the analysis due to very few patients in one of the categories. Prediction models were estimated using a linear mixed model incorporating an AR(1) covariance structure. Our statistical model uses all available follow-up time points (3, 6, 12, and 18 months) for a given patient. Resulting standard goodness-of-fit and residual analyses were unremarkable. The full model, including interactions regardless of statistical significance, was used to estimate least square mean differences between groups for significant variables for ease of clinical interpretation. Univariate p-values are presented for each variable based on the global test for the variable and interactions with time. If desired, the 26 univariate models can be interpreted, adjusting for multiplicity, by the reader using the Bonferroni p-value adjustment (0.05/26 = 0.0019).

RESULTS

There were 50 patients in the operative cohort who met the eligibility criteria for this analysis. A majority of patients undergoing surgery were male (62%; n=31; Table I). The mean age of patients having surgery was 59 years (Standard Deviation=9 years). Most patients were engaged in light or no manual labor for their current or last (in case of retirees or those not working) job (74%; n=37). An equal number of patients were never smokers or past/current smokers (n=24 in each group). Biceps pathology was diagnosed in 30% (n=15) of patients.

A majority of patients had a full-thickness tear (90%; n=43; Table II). The median longitudinal size of the tendon with the largest tear was 2 centimeters (25^{th} percentile=1 centimeter; 75^{th} percentile=6 centimeters) and median transverse size was 2 centimeters

(25th percentile=1 centimeter; 75th percentile=3 centimeters). Grade 0 fatty infiltration was present in 48% of patients (n=23).

In unadjusted multiple comparisons among variables without a significant interaction with time, none of the structural, demographic, symptom, comorbidities, personal habits, shoulder strength, surgical technique, or patient expectation characteristics were significant predictors of SPADI score during follow-up (Table III). When interactions were assessed, FABQ physical activity score and alcohol use were significant predictors of SPADI scores with a differential effect over time. Alcohol use predicted SPADI score in that those consuming alcohol 1–2 times per week or more had lower SPADI scores (better shoulder pain and function) as compared with those consuming alcohol 2–3 times per month or less. The effect size was greatest at 3 months of follow-up and then diminished during subsequent follow-up time points (Figure 1). FABQ physical activity score predicted SPADI such that those with higher FABQ physical activity scores (more fear avoidance behavior) had higher SPADI scores (worse shoulder pain and function). This difference was most pronounced at 3 months of follow-up (Figure 2).

DISCUSSION

We assessed predictors of better outcomes of operative treatment for rotator cuff tears. In a longitudinal analysis, FABQ physical activity score and alcohol use were significant predictors of SPADI score and had an interaction with duration of follow-up. These variables showed a greater effect size during the initial duration of follow-up and the magnitude of their estimates diminished during longer follow-up time points.

Operative treatment is routinely offered to patients with rotator cuff tears. Assessment of better prognostic indicators after operative treatment can help to optimize patient selection and educate patients on expectations of treatment outcomes. Thus, this information can be useful to patients and clinicians.

Castagna et al[4] studied 54 patients undergoing a transtendinous arthroscopic rotator cuff repair for partial-thickness tears. Although this study only assessed partial-thickness tears, less tendon retraction, younger age, and history of trauma were associated with better outcomes. Kamath et al[16] reported on results of arthroscopic repair of high grade partial-thickness rotator cuff tears. Although this study was not specifically designed to assess prognostic factors associated with outcomes, the authors found that the average age of patients with an intact repair at follow-up was significantly lower than those with a persistent defect. Nho et al[21] reported that shoulder strength predicted the American Shoulder and Elbow Surgeons (ASES) score after rotator cuff repair. Gladstone et al[10] assessed 38 patients and reported that muscle atrophy and fatty infiltration were independent predictors of Constant and American Shoulder and Elbow Surgeons scores. In our study, none of the structural characteristics of the rotator cuff including fatty infiltration and muscle atrophy were significant predictors of outcomes. However, there were very few patients with Grade 3 or 4 fatty infiltration in our study because such patients are usually not recommended surgery. Longitudinal size of tear, although not statistically significant in our sample, was the closest measure to achieving significance and potentially could be significant in a larger

sample of patients (p=0.14). Prior studies have reported that a larger tear size is related to worse shoulder outcomes of pain and function[22, 25]. A higher number of comorbidities was not a significant predictor of rotator cuff surgery outcomes in our study. Tashjian et al[28] reported in 151 patients that those with a greater number of comorbidities had worse general health status after a rotator cuff repair but also had a greater improvement in overall shoulder pain, function, and quality of life scores.

Differences in surgical techniques such as single row repair versus double row repair versus transosseous/open repair, and whether or not a biceps tenodesis or tenotomy was performed were not significant predictors of surgical outcomes in our study. There is debate in the literature on whether differences in surgical techniques or adjuvant procedures with rotator cuff surgery impact treatment outcomes. A review from the International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS) concluded that double row repair has not been proven to be more effective than single row in full-thickness tears[1]. Prior literature has also found no significant difference in outcomes in patients that underwent a rotator cuff repair with a tenotomy/tenodesis versus without tenotomy/tenodesis[7,9].

In our analysis, alcohol use and psychosocial factors such as fear avoidance behavior were significant predictors of surgical outcomes. Patients who had a greater fear of physical activity causing increased shoulder pain had worse shoulder pain and functional outcomes after surgery. Most of the effect was seen in the immediate postoperative period at 3 months of follow-up in our analysis. There is increasing literature on the role of psychosocial factors in treatment outcomes of musculoskeletal disorders. Woollard et al[33] assessed factors associated with shoulder disability in 46 patients undergoing surgery for rotator cuff pathology at 6 months of follow-up. Patients underwent either a subacromial decompression or subacromial decompression with a rotator cuff repair. Surgery on the dominant arm and FABQ score were associated with treatment outcomes in the Woollard et al study. It is difficult to explain the association of greater alcohol use with treatment outcomes in our study. However, it is possible that greater alcohol use is a proxy for another variable that was not captured or controlled for in our data and univariate analysis.

Limitations of our study include a relatively small sample size and unavailability of complete data at all of the outcome time points. However, this is one of the few studies to longitudinally assess prognostic factors in patients undergoing operative treatment with a comprehensive set of potential predictor variables.

CONCLUSIONS

Longitudinal predictors of pain and functional outcomes after operative treatment for rotator cuff tears included alcohol use, and those with higher fear avoidance behavior had worse shoulder pain and function at 18 months of follow-up. The greatest effect of these variables was seen in the immediate 3 months follow-up after surgery. These data can be used to select optimal candidates for operative treatment of rotator cuff tears and assist with patient education and expectations prior to treatment.

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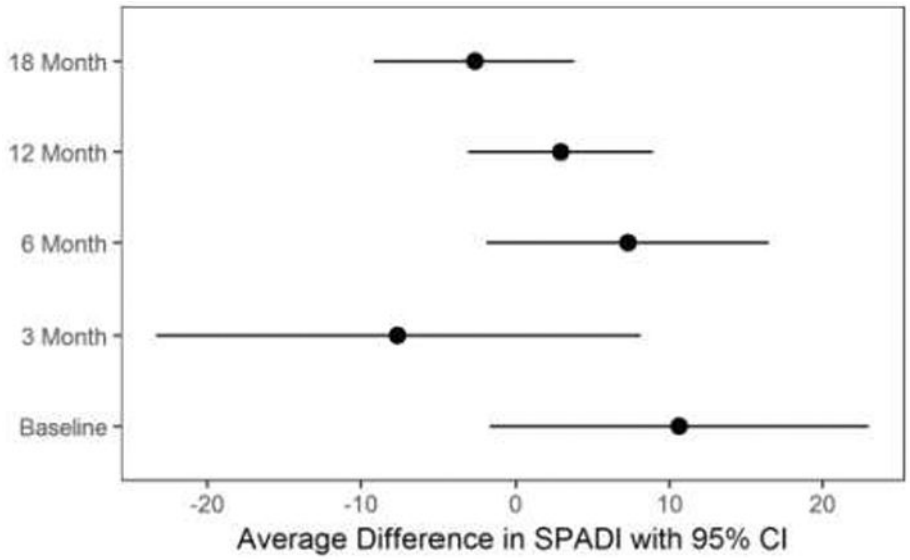

Figure 1: Estimated differences with 95% confidence intervals in SPADI for patients with alcohol consumption of 2–3 times per month or less versus those with 1–2 times per week or more.

Note: Estimated differences at each of the time points is presented given the significant interaction of alcohol use with time. SPADI=Shoulder Pain and Disability Index

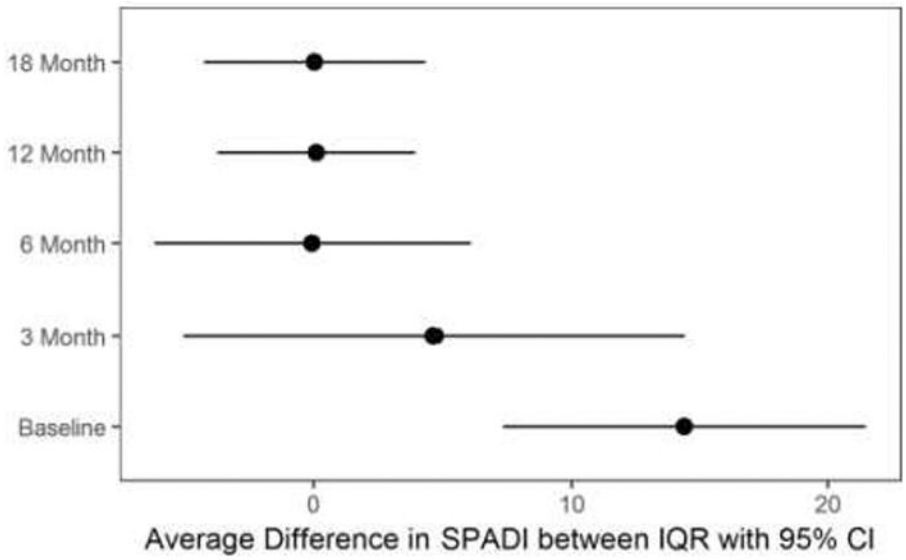

Figure 2: Estimated differences with 95% confidence intervals in SPADI for FABQ physical activity score.

Note: Estimated differences for 75th percentile (23 points) versus 25th percentile (17 points) at each of the time points are presented given the significant interaction of FABQ physical activity with time. SPADI=Shoulder Pain and Disability Index

Table I:

Baseline Characteristics of Patients with Rotator Cuff Tears Having Surgery: The ROW Cohort (n=50)

Characteristics	**Percent of Patients***	**(Number of Patients)****
Demographics		
Sex		
Female	38%	(19)
Male	62%	(31)
Age	52 59 65	(59 ± 9)
Race/Ethnicity		
Non-Hispanic White	92%	(46)
Other	6%	(3)
Missing	2%	(1)
Highest level of education		
Less than college	32%	(16)
College or above	64%	(32)
Missing	4%	(2)
Marital Status		
Single/Divorced/Widowed	22%	(11)
Married	78%	39
Symptoms and Shoulder Strength		
Duration of symptoms (months)	2 6 18	(23 ± 41)
Daily shoulder use at work		
Heavy/Moderate manual labor	24%	(12)
Light/No manual labor	74%	(37)
Missing	2%	(1)
Dominant Shoulder Affected		
No	22%	(11)
Yes	74%	(37)
Missing	4%	(2)
Tear as a result of trauma		
No	46%	(23)
Yes	54%	(27)
External Rotation Strength Ratio¶	0.3 0.5 0.7	(0.5 ± 0.3)
Isolated Abduction Strength Ratio¶	0.8 0.9 1.0	(0.9 ± 0.2)
Comorbidities and Personal Habits		
Number of comorbidities		
≤1	58%	(29)
>1	42%	(21)
Smoking		

Characteristics	Percent of Patients*	(Number of Patients)**
Never	48%	(24)
Past/current	48%	(24)
Missing	4%	(2)
Alcohol Use		
2–3 times per month or less	36%	(18)
1–2 times per week or more	60%	(30)
Missing	4%	(2)
Fear Avoidance and Behavior Physical Activity (FABQ) Score	17.0 19.0 23.0	(19.0 ± 4.0)
Mental Health Inventory (MHI-5)	76.0 85.0 90.0	(80.0 ± 17.0)
Patient Expectations After Treatment		
A great improvement	94%	(47)
Moderate/little/no improvement, or Quality of my life will be worse	6%	(3)
Associated Disorders		
Presence of biceps tendon pathology		
No	70%	(35)
Yes	30%	(15)

n for missing for continuous variables: External rotation strength ratio=4; Isolated abduction strength ratio=7;

* a b c represent the lower quartile a, the median b, and the upper quartile c for continuous variables

** X ± Standard Deviation for continuous variables

¶ Strength ratio is measured as affected shoulder versus unaffected shoulder

Table II:

MRI and Surgical Characteristics of Rotator Cuff Tear in Patients Having Surgery: The ROW Cohort

Rotator cuff tear characteristics	Percent of Patients*	(Number of Patients)**
MRI Characteristics		
Longitudinal size of tear#	1 2 6	(4 ±3)
Transverse size of tear#	1 2 3	(2 ±2)
Cross-sectional area of tear#	2 3 21	(14 ±19)
Thickness of tear//		
Partial-thickness	10%	(5)
Full-thickness	90%	(43)
Fatty infiltration±		
Grade 0	48%	(23)
Grade 1 or more	40%	(19)
Missing	12%	(6)
Muscle Atrophy±		
None/Mild	62%	(30)
Moderate/Severe	25%	(12)
Missing	12%	(6)
Number of tendons torn		
0 or 1	60%	(29)
2 or 3	40%	(19)
Tendon retraction		
Stage I or not applicable¶	60%	(29)
Stage II or more	40%	(19)
Surgical Characteristics		
Biceps tenodesis/tenotomy		
Yes	60%	(30)
No	36%	(18)
Missing	4%	(2)
Type of repair		
Single row	58%	(29)
Double row	24%	(12)
Other	12%	(6)
Missing	6%	(3)

2 patients did not have a MRI available for review so total n for MRI variables in the table is 48

* a b c represent the lower quartile a, the median b, and the upper quartile c for continuous variables

** X ± Standard Deviation for continuous variables

[#] Tear size determined by sum of supraspinatus and infraspinatus tear size in longitudinal or transverse planes for full-thickness tears only; n for missing: transverse size=5; longitudinal size=4; cross-sectional area=5

[Π] If any of the tendons had a full-thickness tear, the tear was classified as full-thickness

[±] Grading reported for muscle most severely affected

[¶] Since tear was partial-thickness

Table III:

Predictors of SPADI Score at 18 months in Patients with Rotator Cuff Tears Having Surgery

Variable	p-value of variable	p-value for interaction of variable with duration of follow-up*
Demographics		
Highest level of education	0.79	0.38
Marital status	0.22	0.92
Sex	0.40	0.99
Age	0.76	0.70
Symptoms and Shoulder Strength		
Duration of symptoms	0.62	0.74
Daily shoulder use at work	0.12	0.69
Tear as a result of trauma	0.74	0.34
Dominant shoulder affected	0.91	0.09
External rotation strength ratio	0.27	0.46
Isolated abduction strength ratio	0.17	0.43
Comorbidities and Personal Habits		
Alcohol use	-	0.02
Fear avoidance and behavior (FABQ) physical activity	-	0.001
Number of Comorbidities	0.98	0.54
Smoking	0.73	0.70
Mental Health Inventory (MHI-5)	0.11	0.28
Associated Disorders		
Presence of biceps tendon pathology	0.49	0.60
Rotator Cuff Tear Characteristics		
Longitudinal size of tear	0.14	0.67
Transverse size of tear	0.30	0.20
Cross-sectional area of tear	0.16	0.42
Number of torn tendons	0.68	0.14
Fatty infiltration	0.18	0.25
Tendon retraction	0.38	0.92
Muscle atrophy	0.48	0.64
Surgical Characteristics		
Biceps tenodesis/tenotomy	0.78	0.32
Type of repair	0.91	0.74

SPADI=Shoulder Pain and Disability Index

Variables significant at $p<0.05$ are reported in *italics*

* If interaction is significant, p-value for variable is not reported